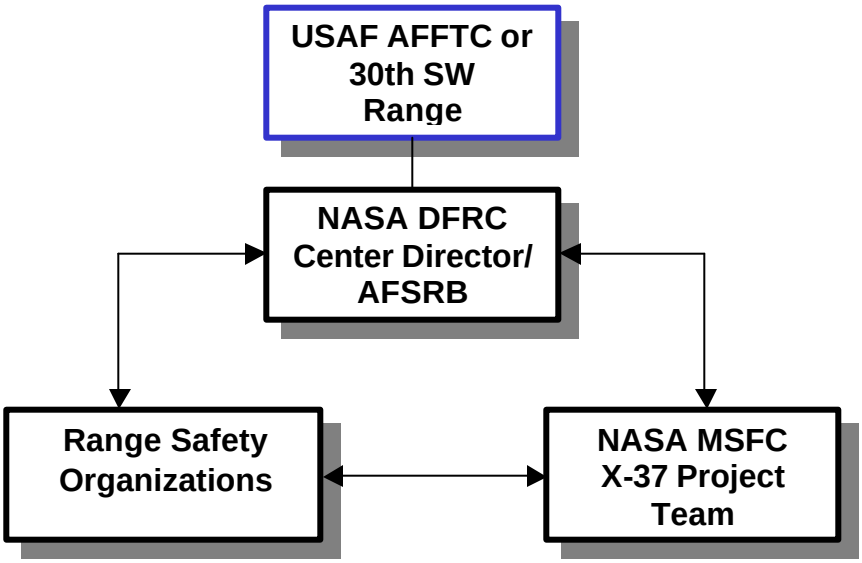
4.8 Operations Assurance Processes

4.8.1 USAF/30th Space Wing/AFFTC

Range Safety

The X-37 landing site(s) identified in Design Reference Missions 1 through 6 are either EAFB or VAFB. Range operations planning is moving forward on this basis and is governed by the AFFTC or 30th SW Range Commanders for landing and operations at VAFB and the DFRC Center Director/AFSRB for landing and operations at DFRC. Figure 4.15 depicts this functional organizational relationship for range safety.

Figure 4.15 Range Safety



Since activities are planned at both sites (altitude drop tests, de-orbit and reentry) operations range approvals are subject to several range safety policies. These are:

- DOD/USAF- DoDD 3200.11 (Major Range and Test Bases)
- NASA NPG 8715.3 (NASA Safety Manual)
- NASA NPG 2810.1 (Security of Information Technology)
- NASA DPD 8740.1 (Range Safety Policy)

Additionally, the X-37 is subject to several range safety processes. These are:

- DoD/USAF EWR/AFFTC 127-1 (Tailored for the X-37)
- DoD/USAF AFI 13-212 (Weapons Range Management)
- DoD/USAF AFFTCI 11-1 (Flight Operations)
- DoD/USAF AFFTCI 91-5 (Test Safety Review)
- NASA DCP-X-009 (Air Worthiness and Safety Review)

- NASA DCP-F XXX (Range Safety Systems Office Organization Process) Draft
- NASA DCP-F XXX (Range Safety Analysis Process) Draft
- NASA DCP-F XXX (Range Safety Officer Process) Draft
- NASA DCP-F XXX (Flight Termination System Process)
- NASA DCP-F-104 (FTS Configuration Control Process)

The overall range safety approval process and the interrelationships between the ranges and the X-37 program office is depicted in figure 4.16.

4.8.2 Flight Termination

One feature of vehicle design that is required due to potential atmospheric flight over populated areas is a flight termination system (FTS). This system consists of laser initiated ordnance used to separate the wings, resulting in loss of aerodynamic lift capability and loss of vehicle. The requirement and implementation of the FTS is governed by EWR 127-1. The Range Control Officer in concert with the X-37 project office will develop and execute agreed upon mission rules and area clearance and termination criteria. The system is single fault tolerant for safety. The system will only be activated should the vehicle stray from its intended flight path during reentry and atmospheric flight.

Since a final decision on a landing site has not yet been made, EWR 127-1 is being tailored to provide a consolidated set of range safety requirements regardless of landing site decision. This involves an ongoing coordination between DFRC/AFFTC/30 SW to support all potential mission scenarios and requirements. Initial de-orbit trajectories have been developed and reviewed (for 28.5, 39.0, 51.6 degrees of inclination) with respect to meeting the Expected Casualty, Ec requirement (see paragraph 4.2.5).

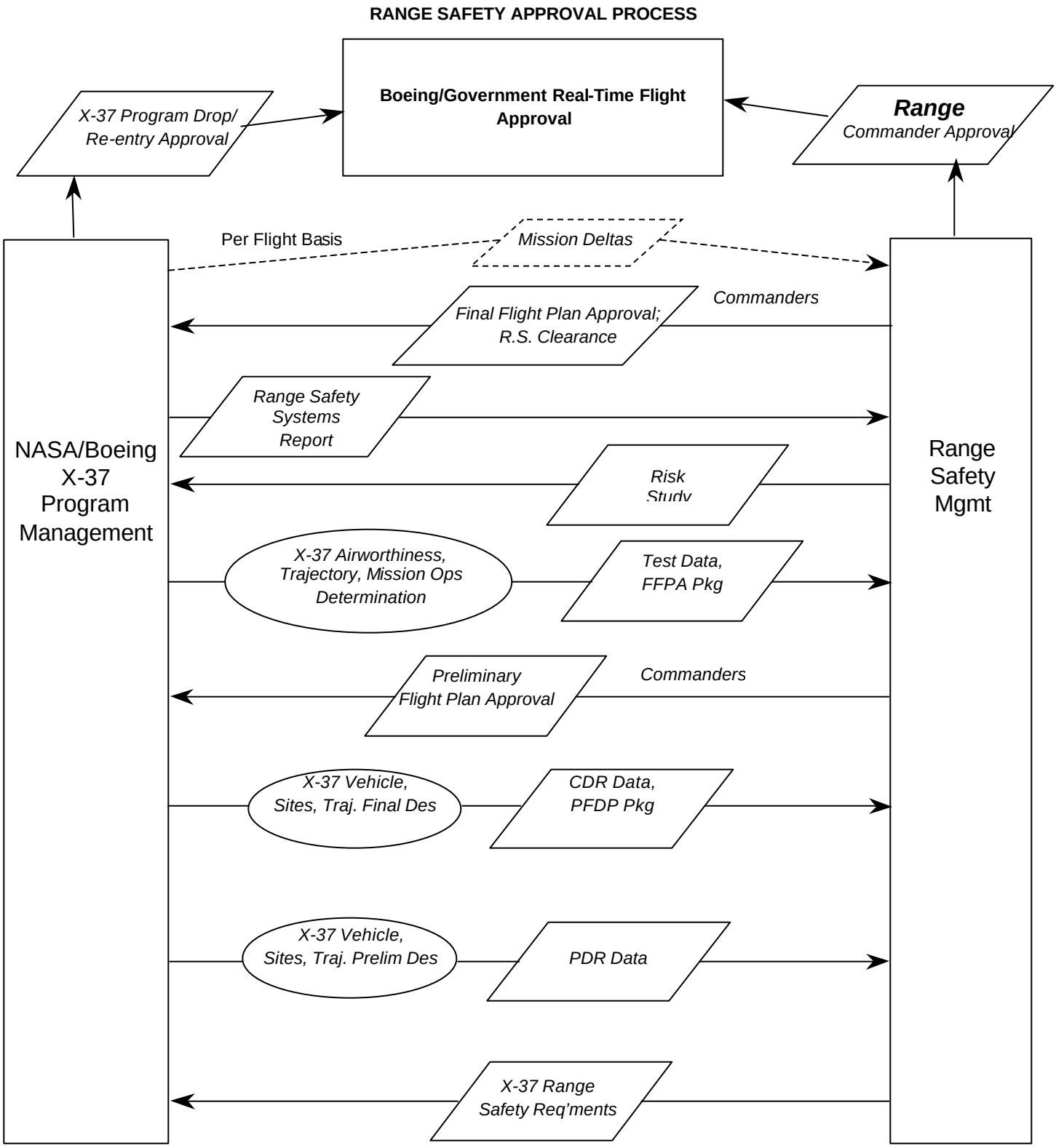


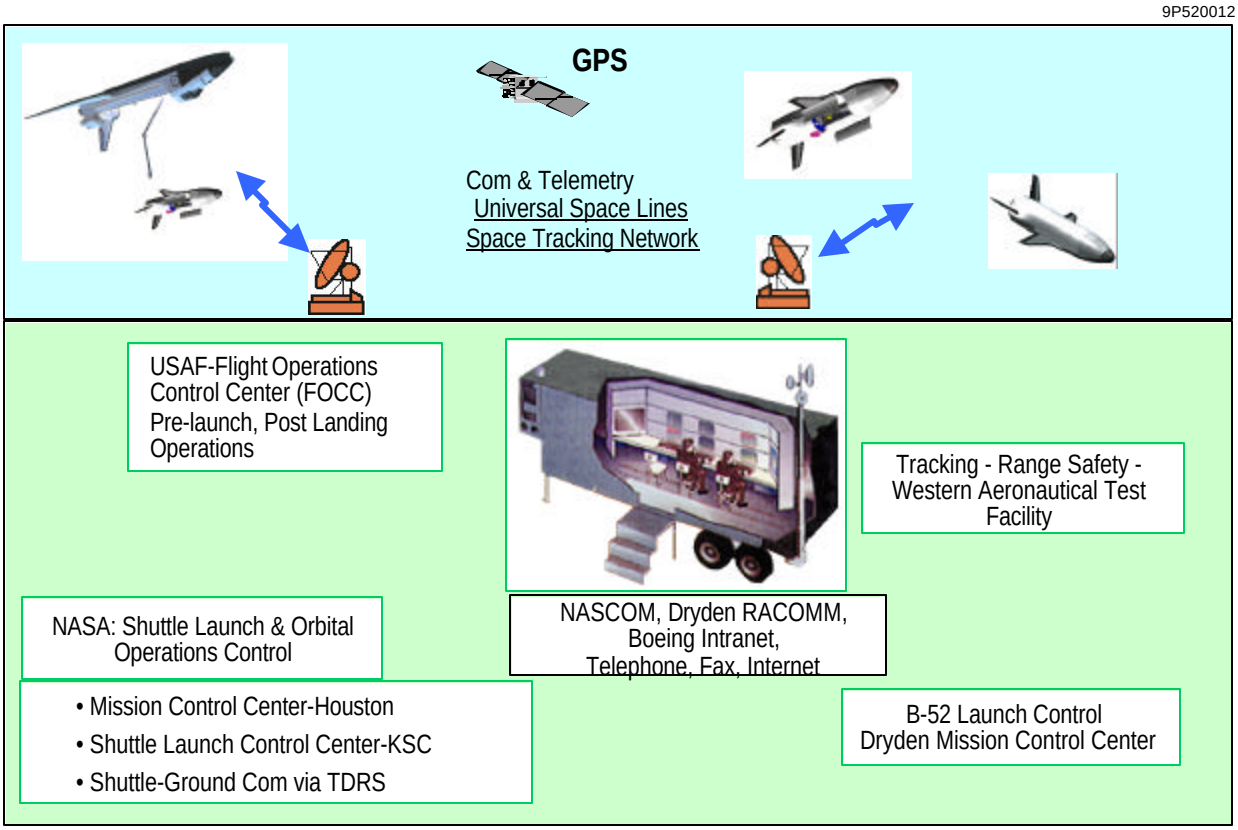
Figure 4.16 Range Safety Approval Process

4.8.3 Flight and Ground Operations

Ground/Flight Operations Control Center (FOCC)

The concept for the X-37 program ground operations is aircraft-like operability and rapid turnaround capability designed into the vehicle. The ground and flight operations equipment elements include the Flight Operations Control Center (FOCC) equipment and software which will be employed for command, control, and data handling of all phases of flight (ALT, On Orbit) and vehicle ground processing and testing. The FOCC is a mobile facility configured with workstations and communication interfaces for range, communication network, and Internet access. Test and ground control software will be used in the FOCC to support training and flight operations. Figure 4.17 depicts the ground segment and FOCC external interfaces.

Figure 4.17 Flight Operations Control Center



Atmospheric Test Phase

The atmospheric test phase is the Approach and Landing Test (ALT), designated DRM-4, to be performed at DFRC and Edwards AFB. The duration is approximately 2 hours. The ferry vehicle will be the Atmospheric Test Launch Vehicle (B-52). A series of drop tests are planned to verify the GN&C control parameters and sensors that control the vehicle from altitudes of 40,000 feet down through the approach, landing, and rollout phase. After release, the X-37 will glide in for an unpowered autonomous landing utilizing the INS/dGPS, calculated air data system (CADS), radar altimeter, and aerosurface controls.

The X–37 ALT program objectives will build upon and extend the testing to date on the X-40A program. X-40A helicopter-launched autocontrol flight demonstrations are complete and data has been incorporated into the GN&C and avionics design of the X-37. While additional drop tests are planned for the X-40A, ground and flight operations lessons learned are being transferred to the X-37 development and operations planning. The X-40A derived flight operations support equipment and procedures are to be upgraded and infused into the X-37 program by an experienced X-40A flight operations team.

The X-37 will undergo a series of towed taxi tests (DRM-3) to demonstrate its ability to navigate and control rollout and verify instrumentation and data collection. These tests are followed by a series of captive-carry flights with the B-52 to verify the flight qualities while attached to the B-52 and vehicle data links (command, control, telemetry, tracking, flight termination). The final series of X-37 tests from the B-52 are five free-flight approach and landing tests to demonstrate unpowered flight and landing characteristics of the X-37.

The X-40A flight tests are designed to help mitigate risks to the X-37 in several areas:

- CADS test and evaluation in an aerodynamic flight environment
- Evaluation of the Honeywell SIGI (GPS/INS) under flight conditions
- FOCC site integration and flight test operation
- Flight test and tune GN&C algorithms
- PID maneuvers to improve the X-37 aerodynamics database

Safety requirements concerning the approach and landing tests, flight demonstrations from the B-52 carrier aircraft, and the return from orbit can be found in both the DFRC DCP-S-002, "Hazard Management," and the Air Force EWR 127-1 documents, as referenced.

Shuttle On Orbit Operations

The X-37 will be delivered to orbit as a payload on board the Space Shuttle where it will accomplish the design requirements for orbital missions, as specified in DRM-2.

During ascent, the X-37 will be in the payload bay and will be supported by two modified Spacelab pallets (one forward and one aft). Also located aft is a launch ring where the X-37 attaches to the Space Shuttle aft fuselage frame via four pyrotechnic bolts and two trunnion mechanisms located on both sides of the X-37 forward fuselage.

Once the X-37 is carried to orbit, the payload bay doors are opened and a limited amount of X-37 vehicle activation and checkout (C/O) is conducted. The intent of the limited C/O is to verify the vehicle is ready for autonomous flight as well as to make sure X-37 vehicle critical systems such as the propulsion system and reaction control system are in a safe state to protect the Space Shuttle crew and vehicle. Upon completion of the C/O, a grapple fixture located on the X-37 upper fuselage is grappled by the Shuttle Remote Manipulator System (SRMS). The trunnion mechanisms are retracted, freeing the forward fuselage on the X-37 from the Spacelab cradle. Using the SRMS, the X-37 is rotated, while still attached to the aft ring, to approximately 30 degrees nose up.

The four pyrotechnic bolts are then fired releasing the vehicle from the aft ring. Once free from its aft ring, the SRMS maneuvers the X-37 to a release point outside the payload bay. At a predetermined point, the X-37 is released from the grapple fixture and the X-37 becomes free in orbit. With the X-37 in free flight the Space Shuttle fires its RCS for a separation burn maneuver so as to increase the distance between itself and the X-37.

When the X-37 is at the minimum safe distance from the Shuttle a command is sent to the X-37 from the ground based FOCC via the Tracking and Data Relay Satellite System (TDRSS). This command triggers the onboard flight management computers (FMC's) and vehicle management computers (VMC's) to load the operational flight software and bring the X-37 vehicle to full activation.

At this point the X-37 vehicle begins its autonomous flight. A flight will last anywhere from 2 to 21 days depending upon the mission objective. During this time the vehicle will perform a variety of flight activities focusing on the demonstration of the 39 embedded technologies. The elements of the On-Orbit Flight Control System (i.e., the INS/GPS and Stellar Attitude Sensors and the primary and vernier RCS thrusters) will be verified.

At the end of orbital operations and system verification, the X-37 will perform de-orbit maneuvers utilizing the AR2-3 engine performing a short burn for reentry and utilizing the primary RCS for de-orbit trim burns. The primary RCS provides a redundant means of de-orbiting the vehicle should the AR2-3 fail. Autonomous atmospheric flight and landing will occur at a selected West Coast landing site. The GN&C system utilizes the automated capability derived from man-in-the-loop Space Shuttle experience. The vehicle design is double fault tolerant for Space Shuttle flight safety and single fault tolerant for mission success.